Participatory three-dimensional mapping for disaster risk reduction

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Introduction

Involving local communities is a prerequisite to sustainable disaster risk reduction. Local communities are both the primary victims and the first to respond to emergencies when disasters strike. Nobody is more interested in reducing disaster risk than the community whose survival and well-being is at stake. Community-based disaster risk reduction (CBDRR) fosters the participation of threatened communities in both the evaluation of risk (including hazards, vulnerability, and capacities) and ways to reduce it. CBDRR should eventually empower communities with self-developed and culturally acceptable ways of coping with crises brought about by the occurrence of natural hazards (e.g. Anderson and Woodrow, 1989). Practitioners often merge CBDRR with community-based adaptation to climate change (CBA) as the ability of people to face climate changes shares root factors with the capacity to cope with natural hazards.

Currently, most CBDRR initiatives are confined to community beneficiaries and NGO facilitators. To further enhance disaster risk reduction, it is acknowledged that CBDRR should integrate a larger array of stakeholders, including local government, scientists, schools pupils, and faith groups. The participation of scientists and local government in CBDRR is essential to integrate indigenous and scientific knowledge, as well as bottom-up and top-down disaster risk reduction measures. Yet scientists have often overlooked CBDRR, considering it to be too subjective and removed from scientific methodologies and rigorous protocols, and local governments are often constrained by top-down, command-and-control national disaster management frameworks which give them little freedom for alternative initiatives. Integrating traditional and scientific knowledge, and bottom-up and top-down risk reduction measures, requires methodologies and tools which provide common ground for dialogue between stakeholders. Such dialogue is crucial to build trust between actors who seldom work together.

This paper focuses on participatory

Figure 1: Building a P3DM map in Divinubo, Eastern Samar, Philippines, August 2007.

three-dimensional mapping (P3DM) as a way to facilitate the integration of both scientific and local knowledge and the participation of a large array of stakeholders in CBDRR. In this article, we first provide a short introduction to participatory mapping and CDBRR. Next, we describe the methodological process for integrating P3DM into CBDRR. Finally, we explore its strengths and also review some of the major limitations of P3DM for CBDRR.

Background: participatory mapping and CBDRR

Maps are extensively used by both scientists and participatory learning and action facilitators as part of CBDRR activities. Participatory mapping enables communities to delineate areas they perceive as vulnerable and prone to hazards, and to plot desired and useful risk reduction measures. Most participatory mapping projects, however, rely on two-dimensional sketch maps. These are usually limited in size, making it difficult to integrate a high level of detail, especially at the household level (number of people, vulnerable individuals, livelihoods, etc.), which are crucial in disaster risk reduction. Furthermore, participatory maps are intelligible only to those who made the maps. It is difficult to foster their use among non-participant stakeholders, especially at the authority level, to integrate top-down risk reduction measures, and as sketch maps are usually not scaled, they may introduce distortions which make it difficult to integrate scientific knowledge.

Participatory three-dimensional modelling or mapping (P3DM) can help in attempting to overcome these shortcomings. It involves building stand-alone scaled relief maps made of locally available materials (e.g. cartons, paper), with thematic layers of geographical information (Rambaldi and Callosa-Tarr, 2002). P3DM enables the plotting of landforms and topographic landmarks, land cover and use, and anthropogenic features, which are depicted in push-pins (points), yarns (lines), and paint (polygons).[1] It is worth mentioning that P3DM most frequently stands for participatory three-dimensional modelling. We here choose to replace 'modelling' by 'mapping' to avoid confusion with technological devices such as computer modelling.

Methodological process for integrating P3DM into CBDRR

P3DM has recently been applied to CBDRR through three projects conducted in the Philippines between 2007 and early 2009, in Divinubo (Eastern Samar), Masantol (Pampanga), and Dagupan (Pangasinan) (Table 1). In Divinubo, P3DM was planned after local officials identified a gap in the existing disaster risk reduction programme. The project eventually involved the scientist facilitators, the local government, and a local people's organisation (PO). In Masantol, P3DM followed a request of the local government which helped to build a consortium of stakeholders made up of scientists, the local government, a local NGO, a PO, and the local high school community. In Dagupan, P3DM was conducted in Mangin as a late part of a large CBDRR project involving officials from local government, a Manila-based NGO, scientists, and members of the local community.

P3DM for CBDRR follows a five-step methodology which blends mapping activities with other participatory tools for assessing and reducing disaster risks (e.g. listing, ranking, calendars, transects, and problem trees).

Step 1 consists of building the relief map as detailed in Rambaldi and Callosa-Tarr (2002) (Figure 1). Most P3DM projects for natural resource management and land conflict resolution use scales ranging from 1:5,000 to 1:10,000. In the three projects described here, much bigger scales were used, ranging from 1:400 to 1:2,700, to allow details of people's vulnerability and capacities at the household level to be shown. In Masantol, however, the 1:2,700 scale proved to be too small to plot the details desired by the different stakeholders.

Step 2 is to plot land use and other georeferenced features (Figure 2). Community members identify features which they depend on for their livelihoods, such as fishing and hunting grounds, agricultural fields, settlements, and roads. Participants then differentiate houses and public or private buildings (e.g. schools, churches, stores) according to their characteristics and potential fragility (e.g. multi-storey cemented houses, one-storey cemented houses, wooden houses). Houses and buildings are plotted using pins of different kinds which may be further divided by size and colour to identify building materials. It is also possible to note on the pins the number of people living in each house and their major sources of income/livelihoods. Participants eventually identify and locate the most vulnerable people in the community (e.g. young children, elderly, pregnant women, individuals with disabilities and long-term sickness) using another sort of pin with different colours. It is then possible to plot local resources to face natural hazards (e.g. boats, vehicles, fire hydrants) using additional pushpins (Figure 3).

Step 3 is to delineate hazard-prone areas based on participants' own knowledge and experience (Figure 4). In Divin-

[1] Further information on building participatory three-dimensional maps is available from Rambaldi and Callosa-Tarr (2002) and the Integrated Approaches to Participatory Development (IAPAD) website: http://ppgis.iapad.org. See also Rambaldi *et al*., (2006).

Table 1: Summary of the three P3DM projects for CBDRR conducted in the Philippines between 2007 and 2009

	Divinubo (Eastern Samar) 2007	Masantol (Pampanga) 2008–09	Dagupan (Pangasinan) 2009
Environmental context	Small island	Deltaic plain	Deltaic plain
Social context	Isolated fishing community	Aquaculture and fishing community	Multi-livelihood suburban community (farming, aquaculture, urban resources)
Main natural hazards	• Tropical cyclone • Storm surge • Earthquake • Tsunami	• Flooding (tidal, pluvial, river-related) • Tropical cyclone • Earthquake • Tsunami	• Flooding (pluvial, river-related) • Tropical cyclone • Earthquake • Tsunami
Origin of the P3DM-CBDRR project	• CBDRR and P3DM project proposed by scientists after identification by the local government of a gap in the disaster risk reduction framework	• CBDRR project requested by local community leaders and the local government • P3DM suggested by scientists	• P3DM requested by NGO partner as part of a large CBDRR project
Participants	• People's organisation • Local government • Scientists	• People's organisation • School community • Local NGO • Local government • Scientists	• People's organisation • National NGO • Local government • Scientists
Scale of the map	1:400	1:2,700	1:500
GIS component	Yes, for scientists	No	Yes, for local government
Main problems encountered	• Lack of local NGO to undertake regular updating of the map and ensure its sustainability	• Scale too small to plot details at the household level (livelihoods and resources to face hazards) • Too many villages covered, not enough participants from each village and thus insufficient knowledge of local households • Availability of pushpins	• Insufficient time to plot data at the household level
Main lessons learnt	• Importance of anticipating power relationships within the community • Importance of P3DM in visualising territories • Use of the third dimension in mapping hazards and risk reduction measures	• School pupils can be important participants • Possibilities for integrating details at the household level • Possibilities for integrating CBDRR into development planning • Importance of P3DM in visualising risks • Importance of partnership with many stakeholders	• Local community may be very creative in overcoming technical shortcomings • Importance of permanent updating • Role of local leaders • Possibilities for integrating CBDRR into development planning • Role of GIS in integrating top-down and bottom-up risk reduction actions

Photo: J-C. Gaillard

Figure 2: P3DM mapping of land cover and other features of the community of Divinubo, Easter Samar, Philippines, August 2007, emphasising indigenous knowledge.

ubo, the neat divide between the island plateau and the low-lying villages surrounding it facilitated the definition of hazard-prone areas. In Masantol, villagers decided to differentiate between three types of floods: river floods, rain-fed floods, and tidal floods. These three types of floods and the different areas they affected had been totally overlooked in the official map drawn by scientists. Once this stage is completed, scientists can then overlap their own spatial knowledge of natural hazards.

Step 4 is to plan disaster risk reduction measures. Multi-stakeholder group discussions take place using the map, and actions are identified. In Divinubo, people agreed upon an agricultural field to be protected in the event of a typhoon. P3DM also enabled them to define and plot measures to be taken in times of crisis. Using the map, community members engaged in discussions regarding warning signals able to cover the entire project area. They plotted meeting points, safe evacuation routes, and shelters (Figure 5). In Masantol, participants located the best places for installing flood markers. They also identified a weak point along a fishpond dike which often collapses under the pressure of cyclonic rains or tidal waters, leading to the long-term flooding of three upstream villages. They decided to create a team with members from the different villages to monitor the dike, and reinforce it in times of very high tides and cyclones.

Step 5: data from the P3DM can be input into a Geographic Information System (GIS) for use by local governments or scientists. In Dagupan, the local government is digitising the map in order to get up-to-date and detailed geo-referenced and scaled information of its jurisdiction. In Divinubo, the P3DM also helped in a scientific study of people's ability to cope with coastal hazards.

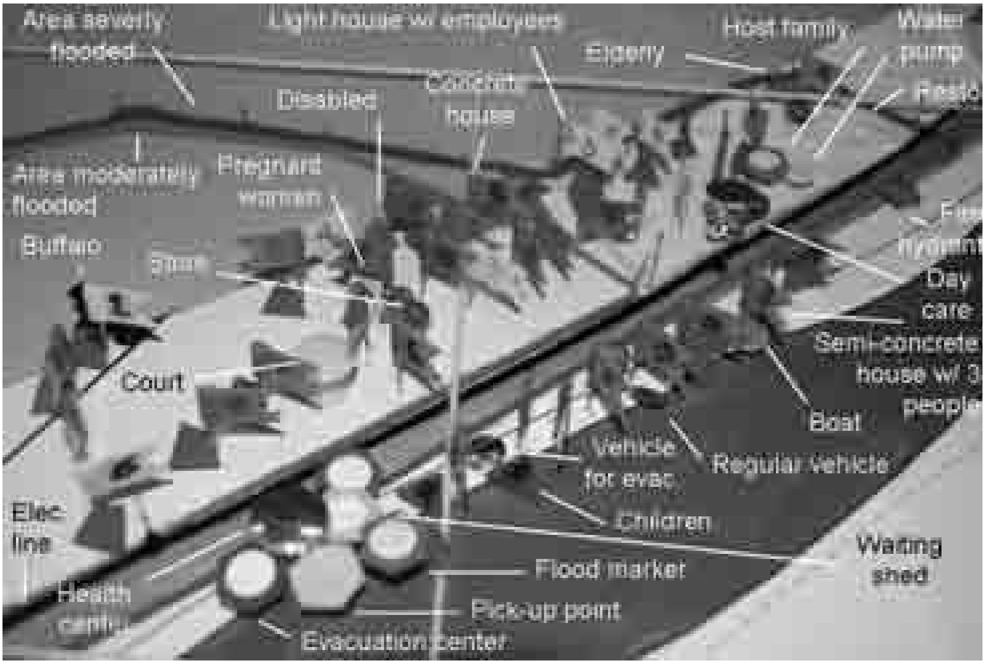

Photo: J-C. Gaillard

Figure 3: P3DM in Dagupan, Pangasinan, Philippines, July 2009.

Strengths of P3DM in reducing disaster risk

P3DM is cost-effective and fosters the use of local materials. The methodology for building the map is also easy to set up and to reproduce. P3DM can facilitate the participation of all sectors of the community, even those often marginalised, such as children, elders, women, and the disabled, through their direct involvement in the construction of a concrete, long-lasting tool for CBDRR.

Building the map in three dimensions and to an exact scale is crucial for the evaluation and reduction of disaster risks. Vertical elevation is essential when the mapping and comprehension of hazard-prone areas requires topographic and elevation references, e.g. for flooding, tsunamis, and landslides. The vertical dimension is also critical for locating refuges and evacuation areas on higher grounds. In the face of rare hazards such as volcanic eruptions or earthquakes, which may be underestimated by local people, the exact scale of P3DM allows scientists to delineate threatened areas as they would usually do on topographic maps or using computer-based tools. Exact scale is important in locating disaster risk reduction measures according to hazard threats and community vulnerability. In Divinubo, the exact scale of the map further proved to be very useful in planning structural measures (a sea wall) intended to protect tourist cottages and a multi-purpose hall.

Vulnerability and risk are abstract concepts which usually materialise only when hazards strike. Showing hazard-prone areas and community characteristics on the same map allows people to identify high-risk areas in their immediate environment. In Masantol, for example, people quickly realised that in one village there were many small coloured flags (representing vulnerable people) and cylinder-like pins (representing vulnerable houses) within a flood-prone area. This prompted them to consider this as a high-risk priority area. P3DM can also be very useful


Photo: J-C. Gaillard

Figure 4: Participants delineating flood-prone areas on a P3DM in Masantol, Pampanga, Philippines, August 2008.

among marginalised communities, such as those living on small islands or in remote rural areas, who are among the most vulnerable to natural hazards. In Divinubo, except for a few men who were more familiar with the island for farming and fishing purposes, people did not have a complete and tangible appraisal of their territory. Most of the participants discovered the real shape, terrain, and land use of the island when building the map.

P3DM fosters the participation of a large range of stakeholders, and collaboration between scientists, government officials, and local communities. It provides a tangible tool around which the most marginalised people, including the illiterate who may have a very poor understanding of scientific concepts, can discuss disaster risk reduction with scientists, who on the other hand may have a poor understanding of the local context. All stakeholders can contribute their knowledge using the same tool. P3DM is credible to

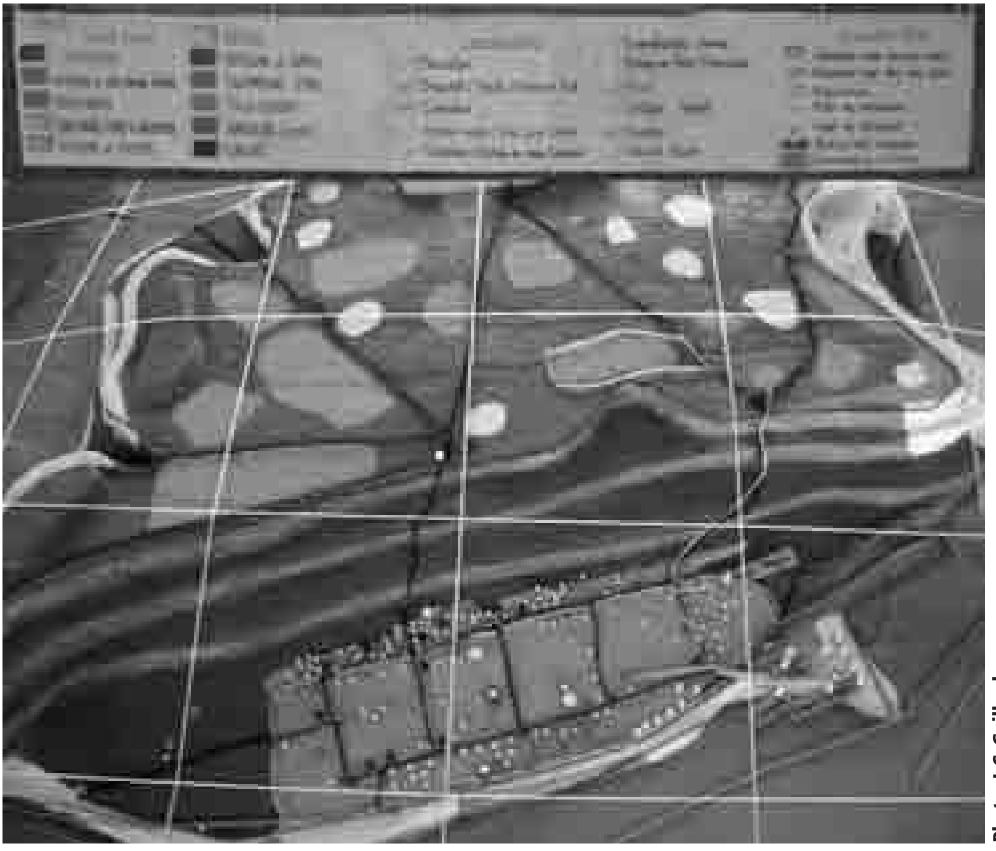

Photo: J-C. Gaillard

Figure 5: P3DM including disaster risk reduction measures in Divinubo, Eastern Samar, Philippines, August 2007.

both locals (including school pupils), who build the map and plot most of the information, and scientists and local government representatives who can easily overlap their own data and plans. In the process, NGO partners serve as facilitators and moderators.

The integration of bottom-up and top-down actions is further facilitated when P3DM data are integrated into GIS to valorise people's indigenous knowledge beyond the community which built the map. This data may be particularly useful for local governments in poor and marginalised regions who are not able to purchase expensive satellite images, and it is much easier and less expensive to update on a regular basis. P3DM offers more information than is usually provided by remote sensing as it can also map underground features such as the types of crop planted in a given area. Finally, P3DM can integrate disaster risk reduction into the larger development framework. In Masantol, participants plan to use the map to locate the best place to construct a bridge linking six isolated villages to the rest of the municipality. The bridge will serve disaster risk-related needs (e.g. evacuation, rescue team access) but also the needs of the villagers who need daily access to public services and commercial places. The map will also be used to settle conflicts between different fishing communities over fishing grounds. In Dagupan, locals use the map for health surveys and feeding programmes.

Limitations and perspectives

P3DM can be a powerful tool but it must be used with care. The initial consultation phase with all potential partners is crucial in ensuring the participation of the largest possible pool of stakeholders, including the marginalised, who are often less visible within the community. A good preliminary knowledge of the local community and a cautious assessment of the needs and expectations of all potential participants are essential. Should these preliminary activities be carefully conducted, P3DM may help empower the most marginalised – both by providing them with access to scientific knowledge and by demonstrating to scientists the credibility of local knowledge. P3DM aims to level power differentials between locals and scientists, one of the main barriers to integrating local and scientific knowledge.

As with all participatory activities (see Chambers, 2008), P3DM raises ethical issues. For example, the data plotted on the map is not anonymous, so sensitive information such as the location of battered wives must be excluded from the map. Who does and who does not own the map is also crucial as it may eventually be used to gain funding or for political advancement. It is important to anticipate potential turnovers in political leadership which may lead, for example, to the abandoning of regular map updates or to a shift in the use and objectives of the map.

It is essential to remember that P3DM is not a stand-alone tool. It does not yet encompass all dimensions of people's vulnerability and capacities in the face of natural and other hazards, particularly social vulnerability/capacities. It is easier to plot infrastructures, houses, and farm lands than client-patron relationships, gender-related inequalities, and social networks. Variation of vulnerability and capacities in time (especially in the short term) according to population mobility, e.g. from home to work places, is another issue still to be addressed on the maps. For these reasons, P3DM needs to be combined with calendars, profiles, transect walks, and other tools common to vulnerability and capacities analysis (VCA) and participatory and learning action approaches (e.g. Wisner, 2006).

The usefulness of P3DM for CBDRR is highly dependent on the scale chosen for the map and whether there is space available for storing it. The best scale for CBDRR seems to range from 1:500 to 1:1000, although the large size of such maps limits their use to a single community. A very fine scale allows working at the household level but requires a sufficient number of participants per community or a series of sessions to be able to get enough data. Those maps are also intended to be updated regularly as infrastructures and social conditions change quickly. Better sustainability is achieved when monitoring and upgrading the map relies on the long-term involvement of mapping facilitators from local NGOs or governments. It is therefore crucial that these stakeholders serve as leading convenors of the P3DM activities at the local level.

More P3DM projects are planned in the near future in the Philippines and also in Indonesia, Comoros, and Cape Verde, and these experiences should help to refine and improve the methodology further.

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